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(71) Applicant(s)

Nippondenso Co Limited

(Incorporated in Japan)

1-1 Showa-Cho, Kariya-City, Aichi-Pref. 448, Japan

(72) Inventor(s)

Shin Kusase  
Atsushi Umeda  
Saburo Hukaya

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(72) cont

Noriyasu Inomata  
Hitoshi Irie  
Hiroshi Ishida

(74) continued overleaf

(54) Magnet holder for a claw pole rotor

(57) A rotor embodiment has sixteen magnets (11), each of which fits between two of sixteen claw-like magnetic poles (15, 16) formed on the outer periphery of Lundell-type pole cores (7) which rotate integrally with a shaft (6). The magnets are held in position by a magnet holder (12) which has been formed by interconnecting zig-zagging segments and has elasticity as a whole. Here, the permanent magnets are held by the magnet holder so that the magnet holder does not protrude towards the rotor side from the outer peripheral face of the Lundell-type pole cores and the contacting faces of the magnet holder contact the outer faces of the permanent magnets. The claw-like magnetic poles are disposed so as to face the stator (2).

FIG. 2

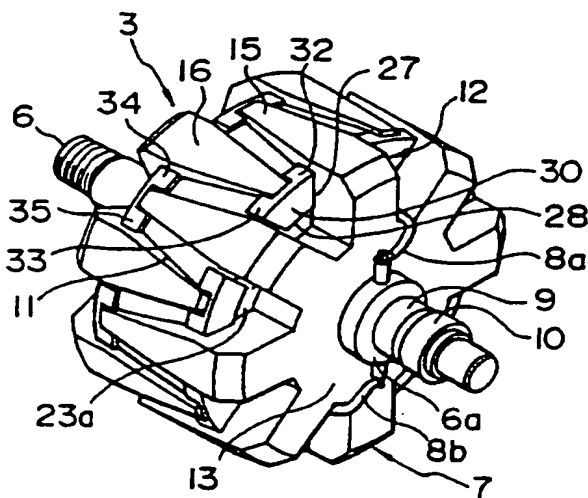
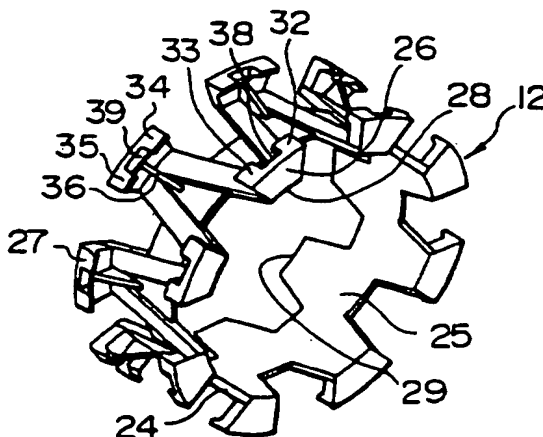


FIG. 5



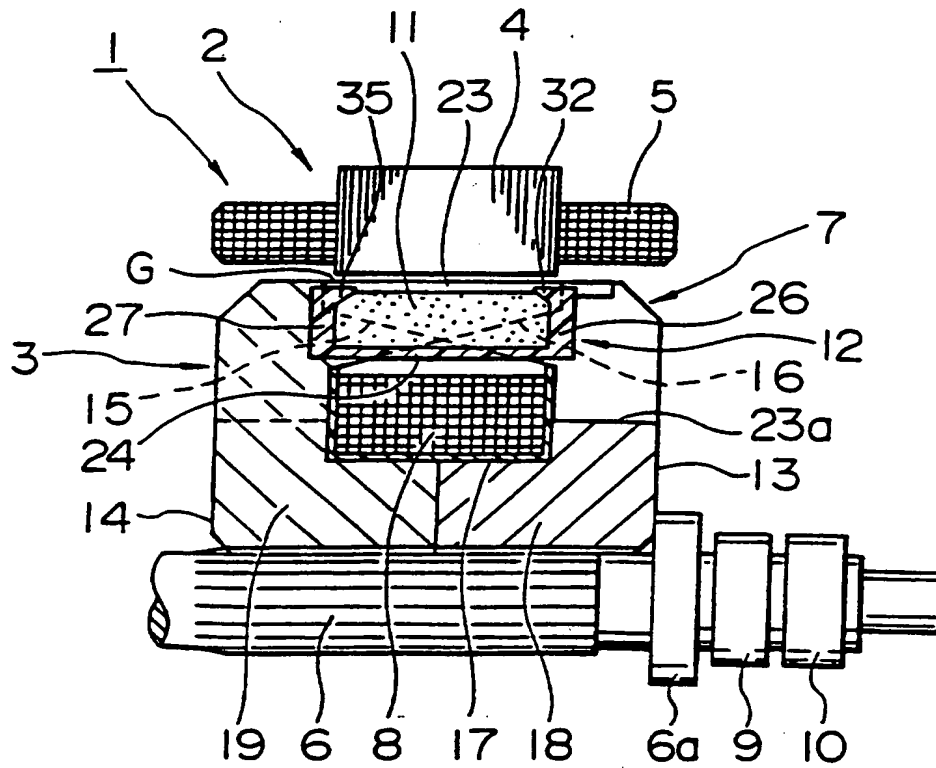
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(74) Agent and/or Address for Service

**D Young & Co**

**21 New Fetter Lane, LONDON, EC4A 1DA,  
United Kingdom**

**FIG. 1**



**FIG. 2**

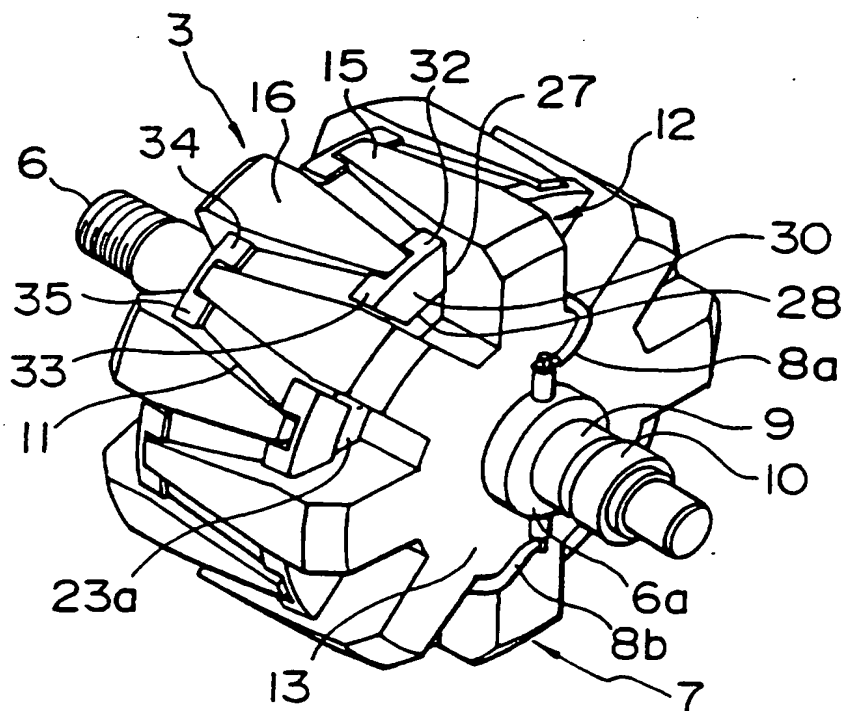


FIG. 3

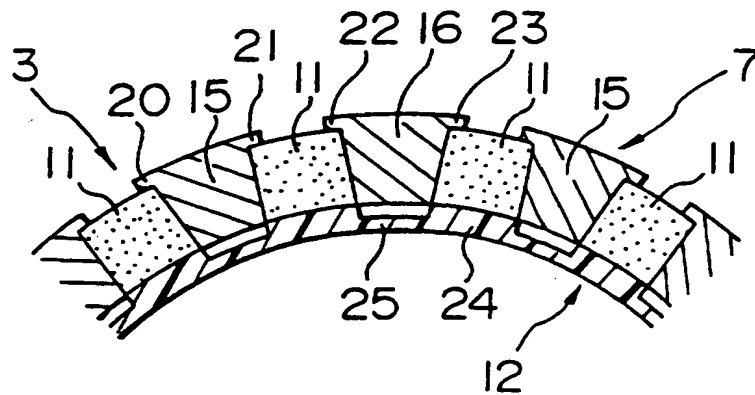


FIG. 4

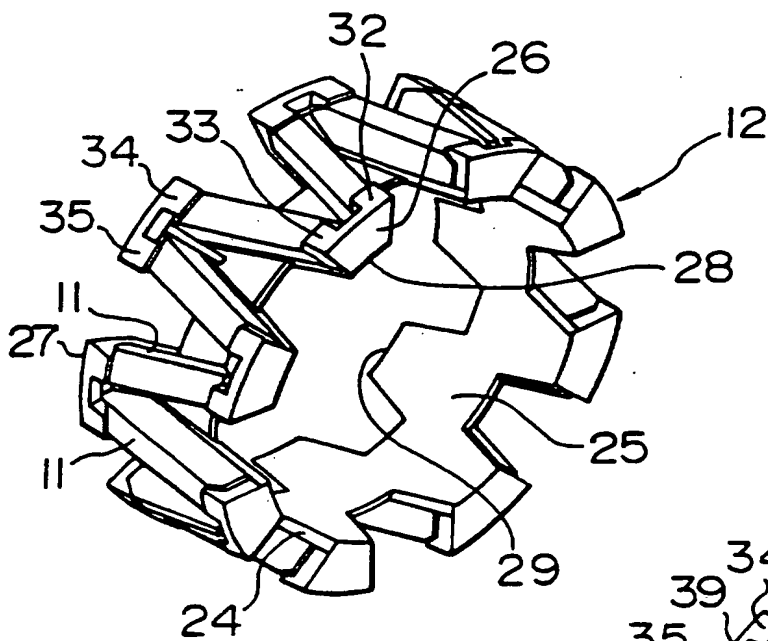


FIG. 5

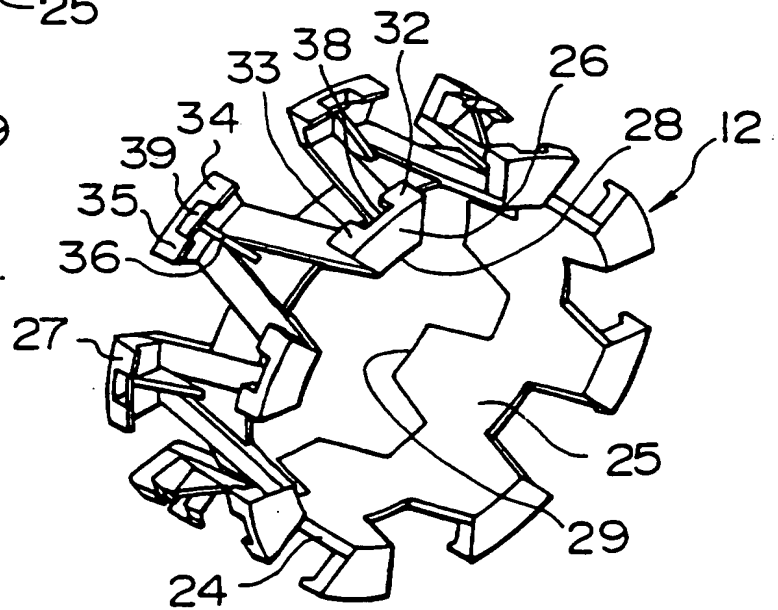


FIG. 6

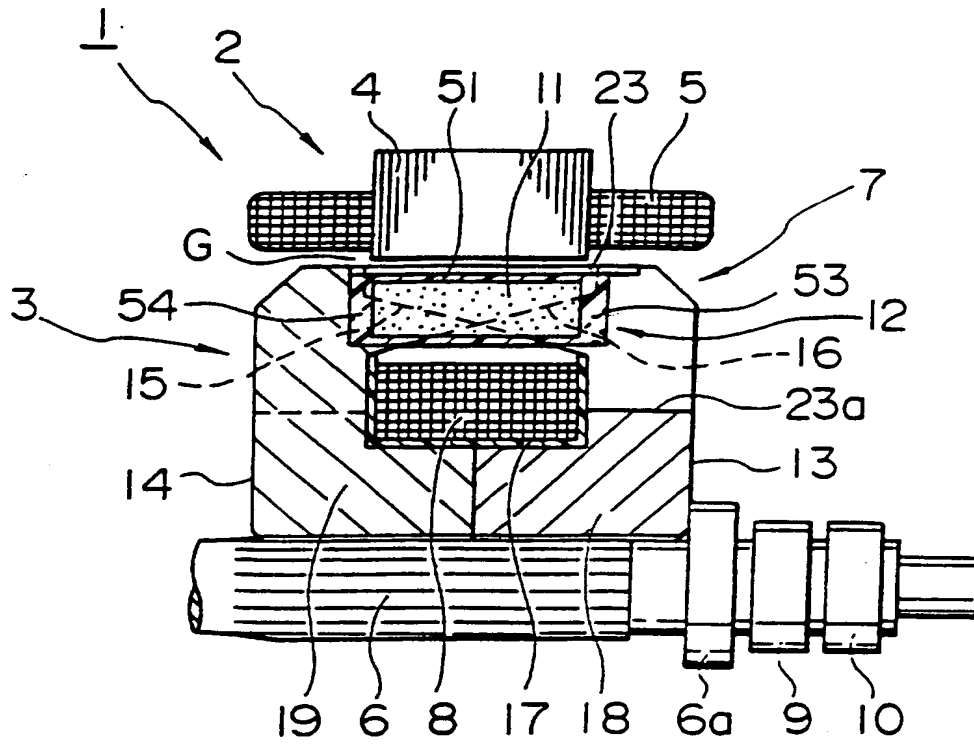


FIG. 7

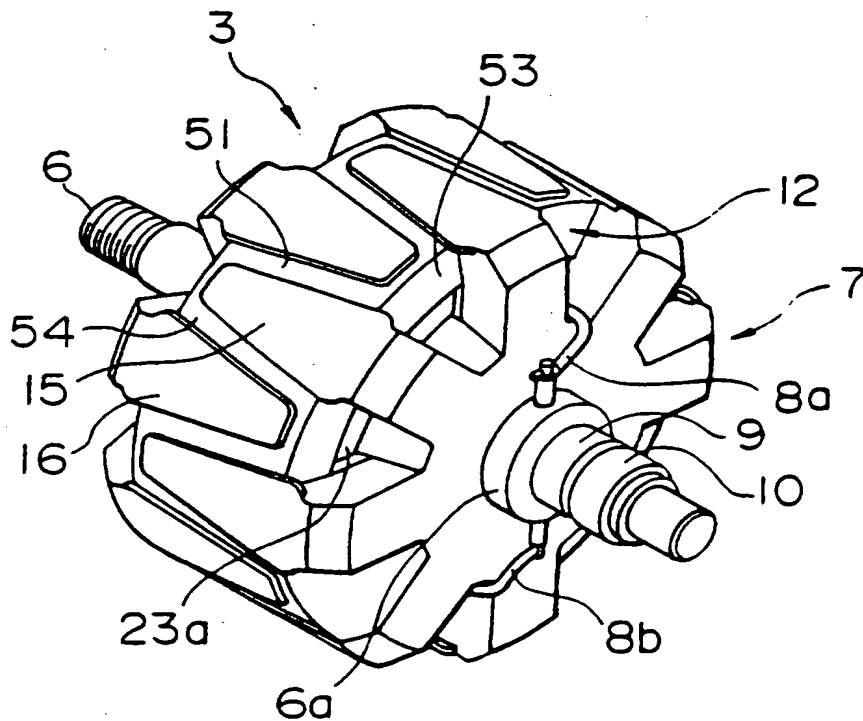


FIG. 8

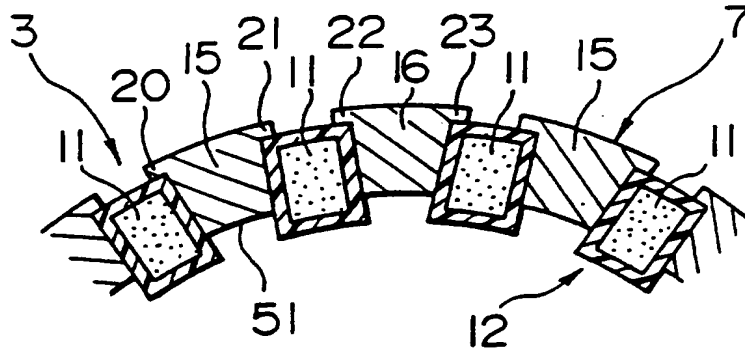


FIG. 9

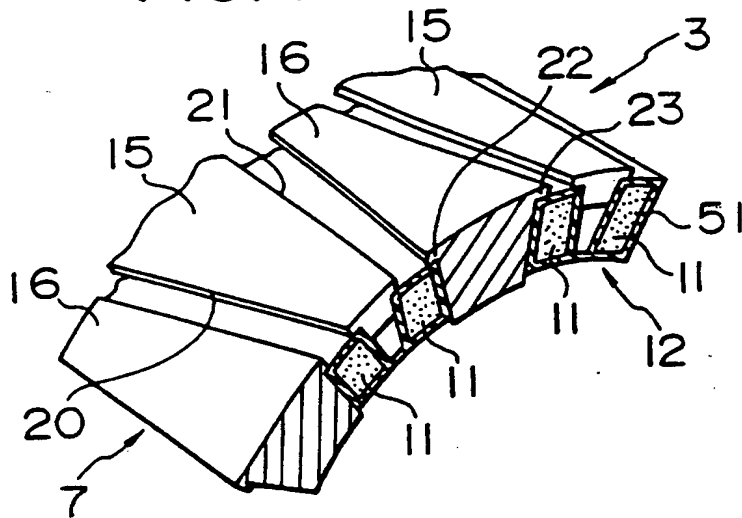


FIG. 10

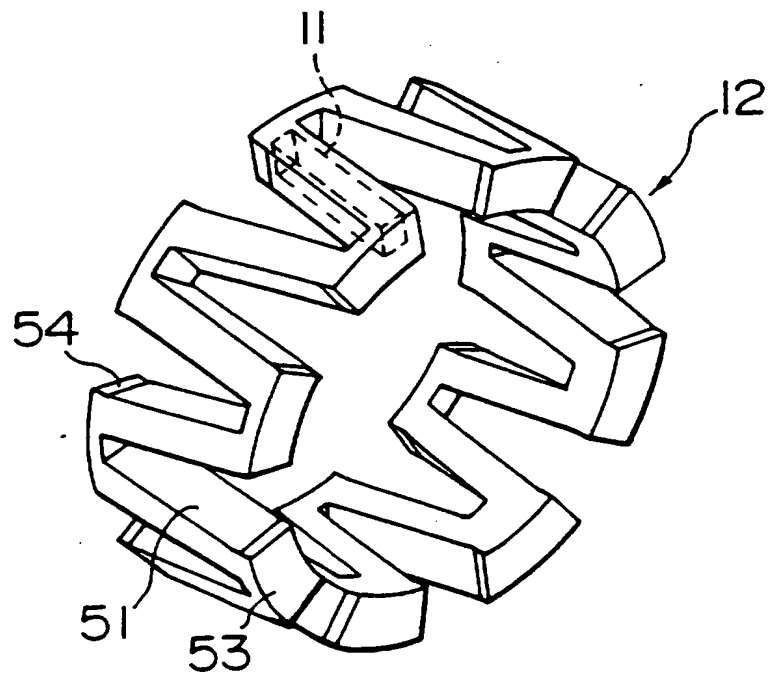


FIG. 11

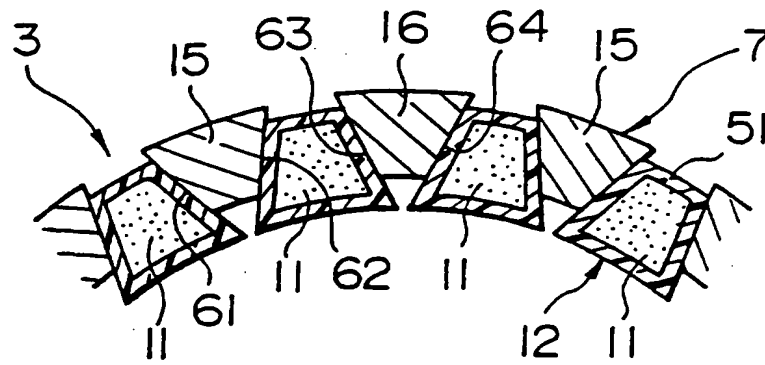


FIG. 12

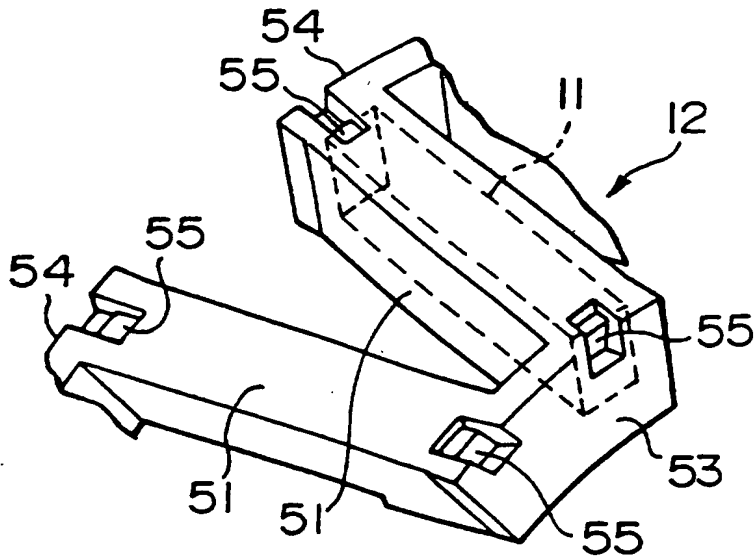
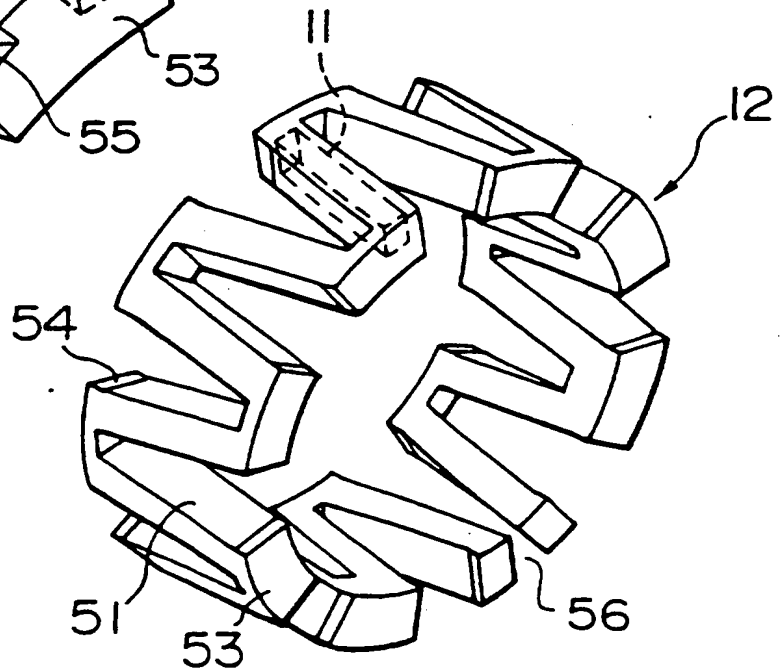


FIG. 13



ROTOR FOR A ROTATING ELECTRIC MACHINE

5           The present invention generally relates to a rotor  
for a rotating electric machine, such as alternating current  
(a.c.) generators and electric motors. More particularly,  
the present invention relates to rotary electric machines,  
which are adapted to hold permanent magnets with a resin-made  
10 magnet holding member, where the permanent magnets are  
disposed between circumferential side faces of two adjacent  
claw-like magnetic poles of Lundell-type pole cores, for  
instance.

15           In a conventional rotor for an a.c. generator, for  
example, it is known that each permanent magnet in the  
generator is inserted between the circumferential side faces  
of two adjacent claw-like magnetic poles of Lundell-type pole  
cores to diminish the magnetic flux leakage between a  
20 plurality of claw-like magnetic poles. At the same time, the  
magnetic flux of the permanent magnets is directed towards  
the field coil (field winding) to improve the output effi-  
ciency, i.e., the electric power generating efficiency of the  
stator coil (armature winding) against the magnetomotive  
25 force of the field coil.

When Lundell-type pole cores rotate, strains are  
generated on the permanent magnets in the direction of the



centrifugal force. Therefore, conventional devices required an arrangement where the permanent magnets would not protrude from the area between the circumferential side faces of two adjacent claw-like magnetic poles.

5           Such a technique is disclosed in, for example, Japanese Unexamined Patent Publication No. 4-165950. This document teaches that the outer face of a rotor, i.e., the outer peripheral face of a plurality of claw-like magnetic poles of Lundell-type pole cores, and the outer faces of  
10 permanent magnets, are covered with a non-magnetic holding member made of a metal such as aluminum.

Furthermore, another technique is disclosed in Japanese Unexamined Patent Publication No. 3-265450. This document discloses that a metal or resin-made non-magnetic ring is  
15 disposed between claw-like magnetic poles of Lundell-type pole cores so that the permanent magnets are held by the non-magnetic ring.

According to the technique disclosed in Japanese Unexamined Patent Publication No. 4-165950, which employs a  
20 construction where the outer peripheral face of a rotor is covered with a non-magnetic holding member, a problem exists where the air gap expands between the outer peripheral faces of the Lundell-type pole cores and the internal peripheral face of the stator core. Thus, the output efficiency, i.e.,  
25 the electric power generating efficiency of the stator coil, is degraded by the expanding air gap between the outer peripheral faces of the Lundell-type pole cores and the

internal peripheral face of the stator core.

Furthermore, the metal-made non-magnetic holding member and the permanent magnets are mounted on the Lundell-type pole cores, which are subjected to the magnetomotive force produced by the field coil. Accordingly, another problem exists, in that high-frequency impact magnetic noise caused by metallic collision noise is made between the claw-like magnetic poles and the non-magnetic holding member due to the vibration conveyed from the Lundell-type pole cores when the Lundell-type pole cores are rotated by rotation of the shaft.

Furthermore, in the technique disclosed in Japanese Unexamined Patent Publication 3-265450, as the non-magnetic ring is formed to have a circular shape with a constant width, strains are generated which deform the non-magnetic ring radially inwardly when a difference in thermal expansion exists between the non-magnetic ring and the claw-like magnetic poles. The non-magnetic ring is often deformed or broken.

#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a rotor for a rotating electric machine which can prevent performance degradation by preventing an air gap from expanding.

It is also an object of the present invention to achieve low noise operation by preventing the generation of

high-frequency impact magnetic noise.

It is another object of the present invention to provide a rotor of a rotating electric machine which can stably hold permanent magnets by absorbing and relieving strains applied to the magnet holding member and at the same time preventing the deformation and breakage of the magnet holding member.

In the present invention, pole cores having a plurality of claw-like magnetic poles formed on the outer periphery thereof are used. The pole cores are assembled so that the claw-like magnetic poles engage with each other and rotate integrally with a rotatable shaft. The present invention further includes a plurality of permanent magnets, each of which is disposed between two adjacent claw-like magnetic poles of the pole cores and magnetized in the direction so as to diminish the magnetic flux leakage between the claw-like magnet poles. Also, the present invention includes a resin-made holding member fit between the circumferential side faces of the two adjacent claw-like magnetic poles to hold the permanent magnets. The resin-made magnet holding member is formed in a ring shape that circuitously completes a 360° circle.

Furthermore, the present invention may be formed such that the resin-made magnet holding member has a plurality of encompassing parts for encompassing or covering and holding each of the permanent magnets. Further, connecting parts interconnect the encompassing parts. The permanent magnets

may be buried in the resin-made magnet holding member.

5 In this arrangement, because the plurality of permanent magnets are buried in the resin-made magnet holding member, it is possible to prevent foreign matter from reaching the magnets, and the formation of cracks in the surfaces of the permanent magnets can be avoided. Moreover, even if cracks were to occur in the permanent magnets, it is possible to prevent the permanent magnets from flying off the rotary device since they are covered with resinous material. 10 Furthermore, the thermal impact due to the severe cooling/heating cycles experienced by a rotating electric machine as well as small vibrations caused by rotation can be eliminated.

15 The present invention may also be formed so that the resin-made magnet holding member is molded with resin in such a manner that only part of the permanent magnet is buried therein. When a plurality of permanent magnets are buried in the molded resin, the permanent magnets can be held using the exposed parts, thus making the positioning of the magnets quite easy to accomplish. 20

25 Furthermore, where the resin-made magnet holding member is formed of resin magnetic material, the magnetic flux of the permanent magnets can be reinforced if the resin-made magnet holding member is magnetized in the same direction as the permanent magnets.

The present invention may also be formed so that the resin-made magnet holding member has board parts, which

contact the inner faces of the permanent magnets, base parts  
for controlling the axial movement of the permanent magnets,  
and catching parts for controlling the radial movement of the  
permanent magnets. Also, the resin-made magnet holding  
5 member holds each of the permanent magnets in a state where  
the opposed faces facing the side faces of the claw-like  
magnetic poles are open and the side faces of the permanent  
magnets contact the side faces of the claw-like magnetic  
poles.

10 In this arrangement, the assembly of the permanent  
magnets to the resin-made magnet holding member can be easily  
performed. As the assembly is performed, the magnetic flux  
can be easily passed through the claw-like magnetic poles by  
having the permanent magnets contact the side faces of the  
15 claw-like magnetic poles.

The present invention may also include a plurality of  
claw-like magnetic poles that are provided with a flange or  
taper shaped catching parts for suppressing the centrifugal  
movement of the resin-made magnet holding member. The size  
20 of the catching parts is set so that the centrifugal force of  
the permanent magnets compresses the resin-made magnet  
holding member on the catching parts. The suppression of the  
permanent magnets and the resin-made holding member in the  
centrifugal direction can be performed with greater preci-  
25 sion, and thus resistance to the centrifugal forces acting on  
the permanent magnets and holding member can be improved.

The rotating electric machine may be an alternating

current generator. The rotor may have Lundell-type pole cores, which allow the resin-made magnet holding member holding the permanent magnets to intervene suitably, and the power generating efficiency can be improved by the permanent magnets.

The resin-made magnet holding member does not have to have both ends thereof interconnected even though it is formed in a circular manner, thus allowing for size differences between the permanent magnets and the resin-made magnet holding member to be easily absorbed. That is, the resin-made holding member may be formed to have a discontinuity therein.

It is also possible for the present invention to include pole cores having a plurality of claw-like magnetic poles formed on the outer periphery thereof, which are assembled so that the claw-like magnetic poles engage with each other and rotate integrally with a rotatable shaft. The present invention may also have a plurality of permanent magnets each of which is disposed between two adjacent claw-like magnetic poles of the pole cores and magnetized in the direction that diminishes the magnetic flux leakage between the claw-like magnet poles. Further, a resin-made holding member may be fit between side faces of the two adjacent claw-like magnetic poles to hold the permanent magnets. The resin-made magnet holding member is preferably formed so that it zig-zags in a complete circle, making repeated V-shaped turns.

According to the present invention, as a plurality of permanent magnets are held by a resin-made magnet holding member fit between the side faces of each two adjacent claw-like magnet poles of Lundell-type pole cores, the gap between the outer peripheral face of the rotor and the inner peripheral face of the stator, i.e., the air gap, does not expand, whereby the degradation in the performance of the rotating electric machine is prevented. Moreover, by suppressing vibrations conveyed from the pole cores to the permanent magnets to prevent the interference between the magnet holding member and the permanent magnets, the generation of high-frequency impact magnetic noise is also suppressed. Furthermore, as the resin-made magnet holding member is formed in a zig-zag ring shape or in repeated V-shaped turns, the elastic deforming force is generated on the whole portion of the resin-made magnet holding member to absorb and relieve strains applied to the magnet holding member.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and characteristics of the present invention along with methods of operation and the functions of interrelated parts will become apparent to a person skilled in the art to which the invention pertains from a study of the following detailed description, the appended claims, and the attached figures, all of which form a part of this specification. In the figures:

FIGURE 1 is a sectional view of the main part of the alternating current generator for a vehicle according to a first embodiment of the present invention;

FIGURE 2 is a perspective side view of the rotor of the alternating current generator illustrated in FIGURE 1;

FIGURE 3 is a sectional view of the main part of the rotor of the alternating current generator illustrated in FIGURE 1;

FIGURE 4 is a perspective side view illustrating the state in which sixteen permanent magnets and a magnet holder are assembled;

FIGURE 5 is a perspective side view of a magnet holder;

FIGURE 6 is a sectional view of the main part of the alternating current generator for a vehicle employed according to a second embodiment of the present invention;

FIGURE 7 is a perspective side view of the rotor of the alternating current generator illustrated in FIGURE 6;

FIGURE 8 is a sectional view of the main part of the rotor of the alternating current generator illustrated in FIGURE 6;

FIGURE 9 is a perspective side view of the main part of the rotor of the alternating current generator illustrated in FIGURE 8;

FIGURE 10 is a perspective side view of a magnet holder with which sixteen permanent magnets are molded;

FIGURE 11 is a sectional view of the main part of the



rotor of the alternating current generator for a vehicle according to a third embodiment of the present invention;

FIGURE 12 is a magnified view of the main part of the magnet holder illustrating the modification where part of the permanent magnet is exposed; and

FIGURE 13 is a perspective side view illustrating the modification where a part of the magnet holder is formed so as to be discontinuous.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED  
EXEMPLARY EMBODIMENTS

FIGURES 1 through 5 illustrate the first embodiment of the present invention. FIGURE 1 illustrates the main part of an alternating current generator for a vehicle, while FIGURES 2 and 3 illustrate a rotor of an alternating current generator, as a rotating electric machine.

Alternating current generator 1 mainly comprises stator 2, which serves as the armature, and a rotor 3 serving as the field. Stator 2 is composed of stator core 4 and stator coils 5, which are supported by a frame (not illustrated). Stator core 4 is formed of overlapping thin sheet steel. A multiplicity of slots (not illustrated) are provided on the internal peripheral face of stator core 4, and three pairs of stator coils 5 are inserted in the slots.

Alternating voltage is generated in stator coils 5 when rotor 3 rotates.

Rotor 3 rotates integrally with shaft 6 and mainly comprises Lundell-type pole cores 7, field coil 8, slip rings 9 and 10, sixteen permanent magnets 11, and magnet holder 12. Shaft 6 is connected to a pulley (not illustrated) and is rotatably driven by an engine (not illustrated) mounted in a vehicle. Ring-shaped stopper 6a is integrally formed on shaft 6 to fix Lundell-type pole cores 7 to the outer periphery of shaft 6.

Lundell-type pole cores 7 comprise circular plate parts 13 and 14 assembled to shaft 6 and eight claw-like magnetic poles 15 and 16 extending from the outer peripheral side of circular plate parts 13 and 14 so that claw-like magnetic poles 15 and 16 engage with one another. It is noted that, in Lundell-type pole cores 7, when an electric current flows through field coil 8, all of claw-like magnetic poles 15 disposed on one axial side are magnetized to the south (S) pole while all of claw-like magnetic poles 16 disposed on the other axial side turn toward the north (N) pole. In the middle part of Lundell-type pole cores 7, wound parts 18 and 19 are formed on which field coil 8 is wound a plurality of times around resin-made bobbin 17.

In the circumferential direction of claw-like magnetic poles 15 and 16, flange parts 20 through 23 (depicted in FIGURE 3) are formed in order to prevent permanent magnets 11 from protruding in the centrifugal direction.

Flange parts 20 through 23 act as stopping parts and catch and prevent the outer peripheral faces of permanent magnets 11 from moving when rotor 3 turns.

5 The first end and last end of field coil 8 are connected to slip rings 9 and 10 via lead wires 8a and 8b. Here, field coil 8 has been impregnated with an epoxy base resin injected from trough 23a formed between the outer peripheral part of circular plate part 13 and the bottom part of claw-like magnetic pole 15. The impregnation is conducted  
10 to prevent the displacement of field coil 8 and also to prevent noise generation.

Slip rings 9 and 10 are mounted on one end of shaft 6 to supply an exciting current to rotating field coil 8. The device is designed so that on the periphery of slip rings  
15 9 and 10, a brush (not illustrated) is provided that slides in order to supply an exciting current.

FIGURE 4 illustrates the state where sixteen permanent magnets 11 are assembled with magnet holder 12. Each of the sixteen permanent magnets is disposed between the circumferential side faces of two adjacent claw-like magnetic  
20 poles 15 and 16 and magnetized in the direction that diminishes the magnetic flux leakage between the two adjacent claw-like magnetic poles 15 and 16. Ferrite magnets, resin magnets formed by sintering the powder of nylon, Nd, Fe and  
25 B, rare earth magnets, or the like, are used as permanent magnets 11.

Both side faces of each permanent magnet 11 contact

the side faces of two adjacent claw-like magnetic poles 15 and 16, respectively. The inner face of each permanent magnet 11, which faces shaft 6, and both axial end faces of each permanent magnet 11 are held by magnet holder 12, while the outer face of each permanent magnet 11 faces the inner peripheral face of stator 2 across an air gap G. The permanent magnet according to the first embodiment has a rectangular, box-like shape with a radial length of 10mm, an axial length of 26mm and a width of 8mm.

FIGURE 5 illustrates magnet holder 12. Magnet holder 12 is a resin-made holding member and is singly molded in one piece using non-magnetic resin material, such as poly-butylene-terephthalate resin (PBT resin) and nylon 66 which contains 40% glass fibers.

Magnet holder 12 has sixteen board parts 24 extending generally axially, each of which holds one of permanent magnets 11 in the state that the end faces of each permanent magnet 11 contact two adjacent claw-like magnetic poles 15 and 16. Connecting parts 25 interconnect boards 24. Connecting parts 25 extending generally circumferentially are disposed so as to relieve strains by providing entire magnet holder 12 with anti-expansion rigidity while ensuring some degree of elasticity and at the same time facilitating assembly. Here, the inner peripheral faces of connecting parts 25 are formed so as to have a generally circular shape.

Sixteen board parts 24, each located between

the side faces of two adjacent claw-like magnetic poles 15 and 16, are formed to have a zig-zag ring shape, which zig-zags back and forth between poles 15 and 16 with repeated V-shaped turns formed at base parts 26 and 27 (described below). On the upper end face (the face on the side opposite shaft 6) of each of board parts 24, permanent magnets 11 are individually placed so that the inner face of each permanent magnet 11 contacts the upper end face respectively.

A pair of base parts 26 and 27 extend radially outward towards stator and are formed from return point parts 28 and 29 of board parts 24. That is, the base parts 26 and 27 extend radially from both axial ends of board parts 24. Here, the inner peripheral faces of the board parts 24 are formed to have a slightly circular arcuate shape.

Permanent magnets 11 fit between base parts 26 and 27 so that the outer face and both side faces of each permanent magnet 11 are exposed. A pair of base parts 26 and 27 contact opposite end faces of each permanent magnet 11 so as to suppress the axial movement of each permanent magnet 11. Base parts 26 and 27 include catching parts 32 through 35 extending axially, which suppress the axial movement of each permanent magnet 11.

Two adjacent board parts 24 meet one another in generally a V-shape at base parts 26 and 27. Triangular partition boards 36 protrude axially from connecting parts 25, and thus maintain a separation between board parts 24. Catching parts 32 and 33 of each base part 26 extend in a

generally V-shape so that the outer end of base part 26 contacts the outer end face of permanent magnet 11. Rectangular slit 38 at which claw-like end of magnetic pole is disposed is provided between catching parts 32 and 33 so as to make it possible to disassemble magnets 11 from the tip of claw-like magnet pole 16 without consuming a great deal of time or effort.

Catching parts 34 and 35 of each base part 27 extend in a generally V-shape so that the outer end of base part 27 contacts the outer end face of permanent magnet 11. That is, catching parts 34 and 35 face catching parts 32 and 33. Rectangular slit 39 is provided between catching parts 34 and 35 so as to make it possible to disassemble magnets 11 from the tip of claw-like magnet pole 15.

The inner peripheral faces of catching parts 32 through 35 are formed so as to be thinner proximate the tip thereof, and the outer peripheral faces of catching parts 32 through 35 are formed so that they have a generally circular arcuate shape.

The method of assembling rotor 3 according to the first embodiment will be described with reference to FIGURES 1 through 5.

First, resin-made magnet holder 12, shown in FIGURE 5, is formed by means of undercutting using a one-way cutting molding die (not illustrated). Each of permanent magnets 11 is fitted between each pair of base parts 26 and 27 of magnet holder 12 to form an assembly such as the one

pictured in FIGURE 4.

By firmly fitting each of permanent magnets 11 between catching parts 32 through 35, as illustrated in FIGURE 4, permanent magnets 11 and magnet holder 12 are assembled. This manner of assembly allows permanent magnets 11 and magnet holder 12 to be put easily together in a short period of time.

Field coil 8 is then wound a plurality of times on the outer periphery of resin-made bobbin 17. Then, circular plate 13, disposed on one side, field coil 8, permanent magnets 11 on the magnet holder 12, and circular plate 14 on the other side of plate 13 are assembled. At this time, as illustrated in FIGURES 2 and 3, the device is structured so that each of permanent magnets 11 is disposed between claw-like magnetic poles 15 and 16. Permanent magnets 11 are caught by flange parts 20 through 23 of the claw-like magnetic poles 15 and 16. Then, after shaft 6 is inserted in the core, slip rings 9 and 10 are mounted on the outer periphery of shaft 6 for manufacturing rotor 3.

Here, as illustrated in FIGURES 1 and 2, the outer diameter of the outer peripheral face of catching parts 32 through 35 of magnet holder 12 is larger than the outer diameter of the outer peripheral face of permanent magnets 11. Furthermore, the outer diameter of the outer peripheral faces of claw-like magnetic poles 15 and 16 is larger than the outer diameter of the outer peripheral face of catching parts 32 through 35 of magnet holder 12. That is, as

permanent magnets 11 and magnet holder 12 do not protrude from the outer peripheral face of Lundell-type pole cores 7, the expansion of air gap G formed between the outer peripheral face of Lundell-type pole cores 7 and the inner peripheral face of stator core 4 can be prevented.

Operation of an alternating current generator for a vehicle according to the first embodiment will be described with reference to FIGURES 1 through 5.

When shaft 6 is rotatably driven by the engine, rotor 3 rotates integrally with shaft 6. Accordingly, permanent magnets 11, each disposed within magnet holder 12 circumferentially between adjacent claw-like magnetic pole 15 on one side of each of permanent magnets 11 and claw-like magnetic pole 16 on the other side, also rotate. Hence, strains are applied on permanent magnets 11 in the direction of the centrifugal force, whereby forces are generated in the radial direction which can move permanent magnets 11.

As each of permanent magnets 11 is fitted between a pair of base parts 26 and 27 of magnet holder 12, and as both ends of the outer face of each of the permanent magnets 11 are caught by catching parts 32 through 35, respectively, permanent magnets 11 are firmly held by magnet holder 12. The configuration, where permanent magnets 11 are firmly held by magnet holder 12 even when strains are applied to permanent magnets 11 in the direction of the centrifugal force, can prevent permanent magnets 11 from protruding from the area between the claw-like magnetic poles 15 and 16.



Furthermore, as the magnet holder 12 is molded in one piece with resin, vibrations caused between the magnet holder 12 and the permanent magnets 11 can be successfully suppressed, while at the same time preventing high-frequency impact magnetic noise.

When an exciting current flows through field coil 8, a magnetomotive force is generated in the field coil 8. At this time, claw-like magnetic pole 15 on one axial side is magnetized to the south (S) pole, and claw-like magnetic pole 16 on the other side is magnetized to the north (N) pole. Then, due to the existence and location of permanent magnets 11, the magnetic flux leakage between claw-like magnetic pole 15 on one side and claw-like magnetic pole 16 on the other side is diminished, and alternating current voltage is generated at stator coils 5 by adding the magnetic flux generated by permanent magnets 11 themselves to the magnetic flux acting on stator core 4.

Moreover, as magnet holder 12 is formed to have a zig-zag circuitous ring shape, which completes 360°, it is possible to provide entire magnet holder 12 with anti-expansion rigidity while ensuring some degree of elasticity, whereby strains can be relieved and assembly is performed easily.

As described above, as alternating current generator 1 is designed to prevent permanent magnets 11 from protruding from the area between the side faces of claw-like magnetic poles 15 and 16, the magnetic flux leakage between adjacent

claw-like magnetic pole 15 and claw-like magnetic pole 16 can be prevented. Furthermore, as permanent magnet 11 is held by magnet holder 12 so that both circumferential side faces of permanent magnet 11 directly contact the side faces of claw-like magnetic poles 15 and 16, the magnetic flux of permanent magnets 11 can be further improved.

Moreover, as magnet holder 12 is molded in a unitary piece from resin, collisions between permanent magnets 11 and magnet holder 12 caused by the vibration of Lundell-type pole cores 7 can be cushioned, thus successfully preventing the generation of high-frequency impact magnetic noise.

Furthermore, as magnet holder 12 is formed in a substantially circular zig-zag ring shape, it is possible to provide the entire magnet holder 12 with anti-expansion rigidity while ensuring some degree of elasticity. Thus, strains caused by a difference in thermal expansion can be relieved and assembly of the device can be performed easily.

In addition, as permanent magnets 11 and magnet holder 12 do not protrude from the outer diameter of Lundell-type pole cores 7, the expansion of air gap G formed between the outer peripheral face of Lundell-type pole cores 7 and the inner peripheral face of stator core 4 can be prevented. Accordingly, the output efficiency, i.e., the generating efficiency of stator coils 5, is improved against the magnetomotive force of field coil 8 of alternating current generator 1.

In this embodiment, an additional quantity of

magnetic flux can be obtained, as compared to a rotor simply using twelve-pole pole cores and twelve permanent magnets, because the present embodiment uses rotor 3 having sixteen-pole Lundell-type pole cores 7 and sixteen permanent magnets 11. This is due to the fact that sixteen-pole Lundell-type pole cores 7 have a larger total sectional area of permanent magnets 11 than do the twelve-pole pole cores. Accordingly, even if the decrease in the magnetomotive force of field coil 8 is taken into account, the output efficiency, i.e., the generating efficiency of stator coil 5 is improved as compared to the conventional technique.

In addition, as rotor 3 is assembled so that permanent magnet 11 is held on both ends by magnet holder 12, the die control and the manufacturing control of the molding pressure, etc., can be simplified as compared to a technique for molding permanent magnets 11. The assembly of the permanent magnets 11 and magnet holder 12 into a single piece can be performed easily, thus reducing the manufacturing cost of rotor 3.

FIGURES 6 through 10 illustrate the second embodiment of the present invention. FIGURE 6 illustrates the main part of an alternating current generator for a vehicle, and FIGURES 7 through 9 illustrate a rotor of a rotating electric machine of an alternating current generator for a vehicle. Similar parts to those described above with respect to the first embodiment are given the same reference numerals in FIGURES 6 through 10.

Rotor 3 of an alternating current generator according to the second embodiment mainly comprises Lundell-type pole cores 7, a field coil 8, two slip rings 9 and 10, sixteen permanent magnets 11, and magnet holder 12 and rotates integrally with shaft 6.

Magnet holder 12 of the second embodiment is illustrated in FIGURE 10. Magnet holder 12 is molded integrally with sixteen permanent magnets 11 using resin material such as poly-butylene-terephthalate resin (PBT resin) and nylon 66 containing 40% glass fibers.

Magnet holder 12 has sixteen encompassing parts or covering 51 and connecting parts 53 and 54, which interconnect encompassing parts 51. The inner peripheral faces of connecting parts 53 and 54 are formed to have a generally arcuate shape.

Each of encompassing parts 51, which is formed as a square, elongated box-like shape so as to encompass each of permanent magnets 11 therein, contains each of permanent magnets 11 in the state where the opposed faces facing the side faces of two adjacent claw-like magnetic poles 15 and 16, the inner face, and the outer face of each permanent magnet 11 are covered with resin. Each of encompassing parts 51 fits between the side faces of two adjacent claw-like magnetic poles 15 and 16. Furthermore, encompassing parts 51 are formed so as to zig-zag back and forth axially and circumferentially between poles 15 and 16 and form a complete 360° band. Also, each of encompassing parts 51 suppresses

the centrifugal movement of a respective permanent magnet 11.

On both axial ends of each of encompassing parts 51, connecting parts 53 and 54 are disposed. Connecting parts 53 and 54 interconnect each two of encompassing parts 51. Two adjacent encompassing parts 51 meet in a V-shape at each of connecting parts 53 and 54. Connecting parts 53 and 54 are thicker at the positions where encompassing parts 51 come together. Connecting parts 53 and 54 are independent elements and correspond to claw-like magnetic poles 15 and 16. The assembly tolerances between claw-like magnetic poles 15 and 16 and magnet holder 12 can be absorbed by modification of each of connecting parts 53 and 54.

In the circumferential direction of claw-like magnetic poles 15 and 16, flange parts 20 through 23 are formed to prevent magnet holder 12 having permanent magnets 11 buried therein from protruding in the centrifugal direction when rotor 3 rotates at high speeds. Flange parts 20 through 23 serve as the catching part and catch the outer faces of encompassing parts 51 of magnet holder 12.

This embodiment, in which the periphery of each of permanent magnets 11 is thoroughly encompassed with resin material, can successfully prevent foreign matter from reaching or entering into permanent magnets 11 and thus assist in preventing cracks from occurring in permanent magnets 11. Moreover, even if cracks occur in permanent magnets 11, it is possible to prevent permanent magnets from flying off as rotor 3 rotates at high speeds as permanent

magnets 11 are totally covered by resin. Furthermore, because each of permanent magnets 11 is encompassed with resin, the magnet holder 12 is able to relieve thermal impact caused by severe heating and cooling cycles. For example, the temperature can reach between 150° and 180°C during generation of electrical power, but returns to ambient air temperature when the power generation process is stopped. Because permanent magnets 11 are covered with resin, they do not experience the extreme thermal impact to which they might otherwise be subjected. The vibrational impact caused by small vibrations of a vehicle also does not crack permanent magnets 11 due to the fact that the magnets are encompassed in resin.

In addition, forces which deform magnet holder 12 radially inward are generated by a difference in the thermal expansion between magnet holder 12 and claw-like magnetic poles 15 and 16. However, due to the shape in which magnet holder 12 is formed, such a deformative force can be absorbed with a spring effect. Here, the expansion of the claw-like magnetic poles in the radial direction caused by the centrifugal force exerted thereon during rotation can also be absorbed, thus preventing breakage of the magnet holder itself.

Moreover, as illustrated in FIGURES 8 and 9, encompassing part 51 intervene between the side faces of permanent magnets 11 and claw-like magnetic poles 15 and 16. By selecting resin material with adequate permanent set (creep

quantity), even if the magnet holder 12 contacts flange parts 20 through 23 at a single point, the resin material alters its shape with the creep of the resin material so that the magnet holder 12 contacts flange parts 20 through 23 in a substantially planar manner, and uniform strain is conveyed to permanent magnets 11 without any concentration or localization of strains, whereby breakage can be prevented.

FIGURE 11 depicts the third embodiment of the present invention and illustrates a partial sectional view of a rotor for a rotating electric machine, such as an alternating current generator for a vehicle.

Taper parts 61 through 64 are formed on claw-like magnetic poles 15 and 16, each of which becomes smaller in width in the vicinity of the shaft core. By catching the outer peripheral face of each encompassing part 51 of magnet holder 12 molded integrally with permanent magnets 11, taper parts 61 through 64 prevent magnet holder 12 from protruding in the centrifugal direction when rotor 3 rotates at a high speed.

The second and third embodiments described above refer to the structure where permanent magnets 11 are completely covered with resin. On the other hand, as illustrated in FIGURE 12, it is acceptable that exposed parts 55 of permanent magnet 11 be provided in resin-made magnet holder 12 and a part of each permanent magnet 11 is exposed through resin-made magnet holder 12 for the purpose of easily burying and molding the permanent magnets 11 in the

resin-made magnet holder 12. Exposed part 55 allows the positioning and fixing of permanent magnets 11 to be performed easily while burying and molding permanent magnets 11.

5 In addition, the magnetic flux can be further improved by making resin-made magnet holder 12 from a resin magnetic material and magnetizing resin-made magnet holder 12 in the same direction as permanent magnets 11 between the claw-like magnetic poles.

10 Furthermore, as illustrated in FIGURE 13, it is acceptable to form resin-made holder 12 with a discontinuity 56 therein. It is also possible that the discontinuity be formed in connecting part 53, thus achieving the same effect.

15 In each of the above-mentioned embodiments, the present invention is applied to rotor 3 of the alternating current generator 1 intended for vehicular use. The present invention is equally applicable to other types of rotary devices. In addition, Lundell-type pole cores 7 are used as pole cores in the disclosed embodiments, but St. Paul-type pole cores can be also used as pole cores.

20 In the above embodiments, because the permanent magnets are held so that the permanent magnets do not protrude radially outward from the outer peripheral face of pole cores, the expansion of the air gap between the stator and the rotor can be prevented, thus avoiding degradation of  
25 the performance of rotating electric machines.

Moreover, as the metallic collision noise caused between the resin-made magnet holding member and permanent



magnets can be suppressed, the generation of high-frequency impact magnetic noise can be prevented.

5 Furthermore, as the entire resin-made magnet holding member has elasticity, strains applied on the magnet holding member can be absorbed and relieved, thus avoiding the deformation and breakage of the magnet holding member and the permanent magnets. Also, the permanent magnets are stably held by the magnet holder.

10 This invention has been described in connection with what are presently considered to be the most practical and preferred embodiments. However, the present invention is not intended to be limited to the disclosed embodiments.

**CLAIMS**

1.     A rotor for a rotating electric machine, comprising:  
a shaft;  
pole cores supported rotatably by said shaft and including a plurality of claw-like magnetic poles disposed around said shaft;  
a plurality of permanent magnets each of which is disposed between a respective adjacent pair of said claw-like magnetic poles and is magnetized in a direction that diminishes magnetic flux leakage between said claw-like magnetic poles; and  
a magnet holding member having a plurality of magnet holding parts holding said permanent magnets and a connecting part connecting said magnet holding parts in the circumferential direction;  
wherein said connecting part is connected to only a part of said magnet holding parts within an entire axial length of said magnet holding parts thereby to provide said magnet holding parts with some degree of elasticity.
2.     A rotor according to claim 1, wherein said connecting part provides connections each connecting a respective two adjacent ones of said magnet holding parts.
3.     A rotor according to claim 2, wherein said respective two adjacent ones of said magnet holding parts extend circumferentially across an axial end of a respective one of said claw-like magnetic poles.
4.     A rotor according to claim 2, wherein said respective two adjacent ones of said magnet holding parts extend axially along a radial inside of a respective one of said claw-like magnetic poles.

5. A rotor according to claim 4, wherein said connecting part has a generally cylindrical shape having a partially cut out portion.
6. A rotor for a rotating electric machine according to any one of claims 1 to 5, wherein said connecting part is connected to said magnet holding parts only at axial ends of said magnet holding parts.
7. A rotor according to any one of claims 1 to 6, wherein each two adjacent ones of said permanent magnets are inclined oppositely in the circumferential direction, said magnet holding parts are inclined correspondingly thereto, and said connecting part is constructed to provide changes in inclination angle of said magnet holding parts.
8. A rotor according to claim 7, wherein said connecting part is connected to the axial ends of each two adjacent ones of said magnet holding parts facing closely to each other.
9. A rotor according to any one of claims 1 to 8, wherein said connecting part is made of resin.
10. A rotor according to claim 9, wherein said magnet holding parts are made of the same resin as said connecting part.
11. A rotor according to any one of claims 1 to 10, wherein each of said magnet holding parts extends longitudinally along a respective one of said permanent magnets and is fitted to the axial ends of said respective one of said permanent magnets.

12. A rotor according to any one of claims 1 to 11, wherein said magnet holding parts cover both circumferential side faces of each permanent magnet which face circumferential side faces of said magnetic poles and cover the radially outer face of each permanent magnet.
13. A rotor according to claim 12, wherein said magnet holding parts also cover the axial end faces of each permanent magnet.
14. A rotor according to any one of claims 1 to 13, wherein said magnetic poles have respective parts which define the position of said magnet holding member in the radial direction.
15. A rotor for a rotating electric machine, comprising:
  - a shaft;
  - pole cores including a plurality of claw-like magnetic poles disposed around said shaft and rotatable by said shaft;
  - a plurality of permanent magnets each of which is disposed between a respective circumferentially adjacent pair of said claw-like magnetic poles and is magnetized in a direction that diminishes magnetic flux leakage between said claw-like magnetic poles; and
  - a magnet holding member disposed between the circumferential side faces of said claw-like magnetic poles so as to hold said permanent magnets, said magnet holding member being shaped so as to follow a path that zig-zags between said claw-like magnetic poles and extends around said shaft.
16. The rotor according to claim 15, wherein said magnet holding member is made of resin.

17. The rotor according to claim 15 or 16, wherein said magnet holding member includes:

a plurality of encompassing parts for encompassing and holding said permanent magnets; and

interconnecting parts for circumferentially connecting said encompassing parts.

18. The rotor according to claim 15, 16 or 17, wherein said magnet holding member is molded so that a part of each of said permanent magnets is exposed.

19. The rotor according to claim 16, wherein said resin-made magnet holding member is made of a magnetic material.

20. The rotor according to claim 15 or 16, wherein said magnet holding member includes:

board-like parts supporting inner faces of said permanent magnets;

base parts extending radially from said board-like parts for suppressing axial movement of said permanent magnets; and

catching parts extending axially from said base parts for suppressing radial movement of said permanent magnets;

wherein said magnet holding member holds said permanent magnets such that their circumferential side faces abut against said circumferential side faces of said claw-like magnetic poles.

21. The rotor according to claim 15 or 16, wherein said claw-like magnetic poles are provided with catching parts extending circumferentially for suppressing radial movement of said magnet holding member.

22. The rotor according to any one of claims 15 to 21, wherein said rotor is suitable for use in an alternating current generator and said rotor has Lundell-type pole cores.
23. The rotor according to any one of claims 15 to 22, wherein said magnet holding member is circumferentially discontinuous.
24. A rotor for a rotating electric machine, comprising:  
a shaft;  
poles cores including a plurality of claw-like magnetic poles disposed around said shaft and rotatable by said shaft;  
a plurality of permanent magnets each of which is disposed between a respective adjacent pair of said claw-like magnetic poles and is magnetized in a direction that diminishes magnetic flux leakage between said claw-like magnetic poles; and  
a magnet holding member disposed between side faces of said claw-like magnetic poles so as to hold said permanent magnets, said magnet holding member being formed in a ring shape having a plurality of generally side-by-side segments joined by V-shaped turns.
25. A rotor for a rotating electric machine, comprising:  
a shaft;  
a plurality of magnets;  
pole cores including a plurality of claw-like magnetic poles disposed so that adjacent claw-like magnetic poles are separated by a respective one of said magnets; and  
means for positioning said plurality of magnets so as to prevent the generation of high frequency impact magnetic noise;

wherein said positioning means includes a holding member having an outermost surface lower than that of said pole cores in the radial direction from said shaft.

26. The rotor according to claim 24 or 25, wherein said holding member is made of resin.



Applicati n N : GB 9700146.5  
Claims searched: 1-14

Examiner: John Cockitt  
Date of search: 4 March 1997

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H2A [AKH1A, AKH2, AKF2, AKC6, AKC7, AKRR]

Int Cl (Ed.6): H02K [01/27, 01/28]

Other:

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
P,X	US5306977A	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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